REGIONAL TRENDS IN THE TAKE-UP OF CLEAN COAL TECHNOLOGIES

John M. Wootten
Vice President
Technology & Environment
Peabody Holding Company, Inc.
St. Louis, Missouri

ABSTRACT

Using surveys of the electricity industry taken in major OECD coal producing/coal consuming regions of North America, Europe, Southern Africa, and Asia/Pacific, this paper reports on the attitudes of power plant operators and developers toward clean coal technologies, the barriers to their use and the policies and measures that might be implemented, if a country or region desired to encourage greater use of clean coal technologies.

I. INTRODUCTION

The Coal Industry Advisory Board (CIAB) serves the International Energy Agency (IEA) as an advisor on issues related to the coal and electricity industries. The CIAB is made up of representatives selected by the governments of the IEA member countries. A series of three papers on industry attitudes toward clean coal technologies for power generation and the factors affecting the take-up of these technologies have been produced by the CIAB for the IEA. As a result of the information put forth in those papers, the IEA Secretariat requested the CIAB to provide its perspective on the potential for the electric power industry to take-up advanced, energy efficient, coal-fired power generation technologies (hereafter referred to as "clean coal technologies") in the near and medium time frame. The CIAB has prepared a report, which is now under review, that presents a region by region assessment of the evolution of these energy efficient, coal-fired technologies by identifying the attitudes towards them, barriers to their take-up, and policies and measures that might be adopted to overcome these barriers. The regional assessment approach is based on the generally accepted premise that the adoption of clean coal technologies will be a function of differing technological, environmental and economic constraints from region to region. While actions on these policies and measures may involve many players, the IEA is particularly interested in CIAB's views on those actions which governments and industry might consider.

The CIAB solicited the views of its members as well as others with electric power industry expertise within four OECD regions of the world, North America, Europe, Southern Africa and Asia/Pacific. Because the previous CIAB studies indicated that a significant amount of the growth in electric generating capacity was projected to occur in the non-OECD countries and particularly the Asia/Pacific region, the CIAB decided to devote a special effort to assessing the attitudes towards the clean coal technologies held by those independent power producers (IPP) who would most likely construct power generation facilities in the developing countries of the Asia/Pacific region. However, the results of the IPP survey are not reported here, but can be found in a paper entitled "Increasing the Efficiency of Coal-Fired Power Generation, State of the Technology: Reality and Perceptions? prepared by Shell Coal International, London, England and SEPRIL Services, Chicago, Illinois.

The clean coal technologies assessed include:

- retrofitting of enhanced controls/repowering existing plants
- the installation of advanced, more efficient steam cycle plants as described in Industry Attitudes To Steam Cycle Clean Coal Technologies, Survey of Current Status (OECD/IEA 1995)
- the development and commercial application of combined cycle technologies as described in Industry Attitudes To Combined Cycle Clean Coal Technologies Survey of Current Status (OECD/IEA 1994)

Again, because the Asia/Pacific region is projected to experience a significant increase in the amount of electric power generating capacity and the technology that is expected to be utilized most often is conventional subcritical pulverized fuel (PF) technology, the CIAB decided to contrast the capital costs, operation and maintenance expenses, reliability of operation and environmental emission characteristics for the conventional PF technology with those of one commercially available clean coal technology, supercritical PF. These results can also be found with the IPP survey results referenced above.

As was deemed appropriate for each region the assessments include:

- consideration of the growth in the demand for electricity in the region and the corresponding generating capacity that will supply that demand segregated by fuel type and technology to the extent possible.
- consideration of the degree of take-up of the clean coal technologies before 2015.
- consideration of likely relative capital costs and the effect on the price of electricity from the clean coal technologies, compared with existing technologies (e.g. taking into account the higher rates of return on investment required to compensate for the perceived extra risk).

- consideration of any extra environmental advantages of the newer technologies. This consideration would need to consider the possibility of the development of more stringent future environmental standards within the region.
- identification of government and private-sector policies, measures and incentives that would enhance the adoption of the clean coal technologies.

This paper summarizes the results of the regional assessments.

II REGIONAL ASSESSMENTS

The attitudes of power generators, both utility and independent power producers, towards the clean coal technologies is expected to be different from region to region because attitudes are influenced by differing technological, environmental and economic constraints. The following discussion is an assessment of these differing attitudes and their implications on the take-up of the clean coal technologies in each region.

OECD North America

Regional attitudes in North America were assessed by examining Canada and the United States.

Canada

The attitudes of the Canadian utility industry towards the take-up of the clean coal technologies is taken from a report entitled "The Potential for Energy Efficient Coal-Fired Power Generation in Canada", prepared by Edmonton Power. This assessment is a compilation of responses from utilities in Canada which collectively represents almost 97% of Canada's electricity generation and all existing coal-fired generation.

Canada is extremely large geographically and, therefore, a diverse nation in many respects, not the least of all in electricity generation. Coal, natural gas and hydro power are readily abundant depending on the Province in question. Nuclear power has been developed extensively in Eastern Canada. Since 1980, new generating capacity has been installed in all parts of the country embracing all "conventional" technologies" with hydro, nuclear and subcritical PF being the dominant technologies. Only one advanced technology has been installed during this period, a 182 MW AFBC unit in Nova Scotia during 1995.

Generating capacity is forecasted to increase 2.8% by 2000 with further increases of 3.0%, 4.3% and 3.4% respectively in each 5-year block until 2015. This represents a modest annual growth rate of 0.68%, while energy consumption is expected to increase by 1.38% per year until 2015. Of the new capacity being added, 15.9% is expected to be coal-fired and 49.8% is expected to rely on natural gas. Repowering with the addition of a gas turbine and life extension with improved unit efficiency will also play major roles in fulfilling new capacity requirements.

In choosing the types of new capacity, capital and fuel costs were cited as the top two determining factors, followed by environmental considerations, plant availability, return on capital invested, construction time, and security of fuel supply. In those Provinces where deregulation is occurring, the higher risk of not recovering costs makes the reduction of investment risk through shorter planning, design and construction times a key factor. CO2 is considered the most important environmental factor, followed by SO2, NOx and siting considerations.

The potential for the take-up of the clean coal technologies in Canada is relatively low with the limited addition of coal based capacity. The expressed interest is in IGCC technology to be installed after 2006. Interest in the other technologies will be dependent on their commercial maturity and economics in the same time frame.

The barriers to the clean coal technologies are increased deregulation of the electric industry with the delay of long-term decisions due to uncertainty, increasing environmental limitations and costs associated with coal-fired technologies, increasing complexity of financing arrangements and in a deregulated market, gas will be very competitive with coal.

In those locations where gas is readily available and competitively priced, it will act as a barrier to the take-up of clean coal technologies. In addition, proof of performance in the areas of environment, reliability, operability and power cost at a commercial scale in a utility environment is needed. Similarly, the capital cost and construction time of the clean coal technologies must be reduced. Proposals under consideration to control/tax greenhouse gases are seen as limiting the opportunities for coal based technologies.

Government policies to overcome these barriers should address two areas; funding a substantial portion of up-front R&D and demonstrations consistent with long-term environmental policies and favorable tax/depreciation for environmentally sound technologies requiring penetration assistance.

United States

The attitudes of electricity producers in the US towards the take-up of advanced energy efficient, coal-fired technologies is assessed in the report entitled “Regional Trends in the Evolution of Energy Efficient, Coal-Fired Power Generation Technologies in the United

States", Prepared by Peabody Holding Company, Inc. The assessment is based on published information which reports the results of surveys of electric utilities and independent power producers attitudes towards clean coal technologies. Since 1986 the US Department of Energy (DOE) has been administering a government/industry co-funded program to demonstrate clean coal technologies at a utility scale. The Clean Coal Technology (CCT) program has resulted in a US $6.9 billion effort for the first-of-a-kind or early commercial demonstration of the clean coal technologies that the CIAB has previously reported to the OECD/IEA. The attitudes reported here are influenced by the experiences learned in the CCT program.

Kilowatt hour sales in the US are expected to increase by 31% for the period 1995 to 2015. During that same period net generating capacity additions are expected to increase by 22% or 167 gigawatts (GW). New capacity additions plus replacement capacity for retired units is expected to be 252 GW. Coal-fired capacity additions are projected to increase by 5% or 15 GW. Natural gas-fired capacity will dominate with a 69% increase or 166 GW while nuclear capacity will decrease by 36% or 35 GW. The majority of the nuclear reductions are projected to occur after 2010 when most of the plants' current licenses expire. The projections do not reflect any changes that may occur as a result of the deregulation of the US electric industry.

The potential for the take-up of the clean coal technologies exists in the 252 GW of new or replacement capacity. However, this potential is influenced by a number of attitudes of the user community. The opportunities for base load units are limited before 2000 and increase to some extent between 2000 and 2005. The clean coal technologies are viewed as having higher capital and operating costs relative to subcritical PF technology. Subcritical PF appears to be the coal technology of choice despite the fact that supercritical PF is viewed as a proven, reliable technology. IGCC is viewed as somewhat proven/reliable, while PFBC is viewed as not proven. Strong interest exists in life-extension and improving performance at existing plants. In addition, deregulation is delaying, indefinitely, long-term decisions for additional generating capacity.

The barriers identified to the take-up of the clean coal technologies are many. Coal continues to a have a poor public and political image even though the clean coal technologies offer the promise of significant efficiency improvements and reduced environmental impact. Coal remains the fuel-of-choice for base load applications. Where natural gas is readily available and competitively priced, natural gas will continue as the fuel-of-choice for incremental capacity additions. Concern exists over the future regulation of CO2. Life cycle costs are less important and decisions are being driven by short-term considerations related to financial risk.

Policies and measures that could be implemented center around two areas - technology transfer and economic incentives. The attitudes of the electric utility industry indicated a lack of knowledge and perhaps an excessive degree of risk aversion concerning the commercial status, costs and reliability of the clean coal technologies and, in particular, supercritical PF. A better job needs to be done to market the clean coal technologies by

providing more information on risks and costs. This program should be targeted at non-utility generators because of their future role in providing new capacity additions. Finally, without some program of cost sharing to reduce risk, the clean coal technologies are unlikely to be taken-up to any significant extent before 2005. Financial incentives that have been explored are subsidies and special tax/depreciation treatment.

OECD Europe

In Europe, the attitudes of 16 OECD member countries were solicited and the findings are contained in the report entitled "Regional Studies on Evolution of Power Generation, OECD Europe", S-K Power, Denmark. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Spain and the UK responded to the request for information and these 13 countries represent OECD Europe for purposes of this paper. In addition, information was requested for the 20 year period 1995 through 2015. However, not all respondents were willing to provide information for the 2010-2015 timeframe and those that did respond, had strong reservations about the reliability of the data. Therefore, the time frame for OECD Europe information is 1995 through 2010.

The OECD Europe electric power industry expects a fairly constant load growth over the period from 1995-2010, to the order of some 16% growth in capacity and a higher 27% growth in energy use.

As a consequence of the on-going transition of the industry from one of monopolies to a deregulated competitive market, power companies have redefined their earlier strategic/politically based objectives (technological reliability/availability, fuel flexibility and use of indigenous fuels) to economic ones like return on investment and capital cost. At the same time, environmental considerations are expected to continue to play an important role in the future choice of generating capacity.

European power companies expect oil to lose ground as an energy source in Europe over the next 15 years; while coal and nuclear should maintain the status quo; and hydropower should see a small increase. Capacity based on renewable fuels will enjoy a large increase, but even so, it will remain an incremental energy source.

Natural gas fired technologies with their relatively low capital costs and environmentally friendly image will supply most of the growth. This is remarkable because even though most European power companies agree that "Europe is becoming too dependent on imported natural gas", they still plan to select natural gas as their fuel for new capacity.

In comparison to gas, the expectation for the installation of new coal based capacity is low. Coal-fired capacity, that will be built over the next 10 years, will be supercritical PF technology. After 2005, the choice of clean coal technologies will be dependent on their state of development at that time.

The main barriers to the enhanced take-up of the clean coal technologies are economic in nature (e.g. high capital costs) and except for countries already hosting demonstrations of clean coal technologies, a skeptical view of the maturity of the PFBC and IGCC exists. Furthermore, coal has a public/political image problem.

Various proposals have been put forward by the power companies to overcome the barriers to the take-up of the clean coal technologies. As regards high capital costs, suggestions include political support of the continued development and dissemination of the clean coal technologies through subsidies, financing or funding. Preferential treatment in the market place of the electrical output from the clean coal technologies is another possible approach.

When it comes to overcoming the skepticism on the maturity of PFBC and IGCC technologies, the fact that countries hosting the technologies have a strong confidence in their virtues could indicate that a better dissemination of demonstration plant locations could constitute an effective way of proving their commercial readiness to a broader audience.

Finally, proposals to overcome environmental (including public and political image problems) barriers entail providing more information on the virtues of coal as a fuel, e.g. the large and geographically widespread resource base and the advanced technological state of today's coal mining and coal usage facilities. Further, the implementation of closed handling systems at harbors and power plants might be beneficial to coal's image.

Southern Africa

The Southern Africa assessment presents the views of developing countries whose primary emphasis is regional development and the role that power generation plays in that development. Limited information is presented for 15 sub-Saharan Africa countries and detail information is presented for South Africa in the report entitled "Evolution of Power Generation, Southern Africa Study", prepared by the ESKOM Technology Group. During 1995, South Africa accounted for 76% of the generating capacity for the region and produced 83% of the electrical generation. As a result the regional information is to be considered quantitative at best.

The perspective from the Southern Africa region is fundamentally different than for developed OECD countries. Development is focused on local and regional issues and attempts to maximize international cooperation to ensure that development is optimized. This entails securing clean coal technologies during development with the incremental costs above conventional technology being borne by the developed countries. This approach has been referred to as "Activities Implemented Jointly" in the context of reducing environmental impacts.

The 1995 electricity supply and demand situation for the 16 sub-Saharan African countries is one of significant over supply. The region has a total of 46 GW of installed capacity and electricity production totaled 207,545 GWh which represents 52% of the potential production. Under current projections, it is unlikely that additional capacity will be required in the region before the year 2010. Excess capacity in the region may be optimally utilized via the Southern African Power Pool. However, issues such as the reliability of long transmission lines, coupled with individual national priorities could result in additional capacity being built before 2010. Any increase in capacity will, in all likelihood, be met predominately by coal in South Africa and by hydro in the other countries in the region. In addition, South Africa has introduced a demand side management program as an alternative to capacity additions.

In spite of the over supply situation and because future growth is highly uncertain, supply side options are being evaluated for future applications. Clean coal technologies are being evaluated with the objective of reducing lead time, capital and operating costs, environmental impacts and optimizing unit size and load following capability. Environmental impacts focus on local and regional impacts with a lower priority on global impacts.

Clearly the most significant barrier to the take-up of clean coal technologies in Southern Africa is the excess of generating capacity which is expected to exist until after 2010. Other potential barriers include: perceptions of unreliability and higher operating costs, limited local skills and infrastructure, competition from other fuels such as hydro, gas and possibly nuclear. Also the existing capacity is relatively new (11-15 years) and retirement and replacement with clean coal technologies has a low potential.

Realizing that capacity is not needed in Southern Africa till after 2010, options open to both governments and industry to overcome the barriers from a developing nations point of view include means to catalyze economic growth, funding of the premium for the installation of clean coal technologies by the developed nations, demonstrations in developing countries, a robust program for disseminating information on the technologies and development of human capabilities in developing countries.

OECD Asia/Pacific

The assessment of the OECD Asia/Pacific region consists of a compilation of attitudes in three countries: Australia, New Zealand and Japan.

Australia/New Zealand

Australia and New Zealand constitute a region of the world where government has recently promoted competition in the electric power industry. This has developed an opportunistic approach and less certainty in the type and timing of new generation plant

additions. The assessment of the take-up of clean coal technologies reflects this change in the electric industry and is presented in detail in the report entitled "Regional Studies On Evolution Of Power Generation Australia and New Zealand", prepared by Sligar and Associates Pty. Ltd., New South Wales, Australia on behalf of CRA Limited.

Load growth in Australia and New Zealand is expected to average 2% per year through 2015. This low predicted growth, coupled with existing reserve margin in some areas and the developing highly competitive situation, will lead to new generation initiatives in the near future. New generation will be incremental in nature and with the deregulation of the Australian gas industry will favor gas as the fuel-of-choice. A major portion of the coal capacity has recently been retrofitted and further refits are scheduled before 2000. The retrofits consist of minor technology advances and it is unlikely that these refits will employ any clean coal technology, e.g. IGCC.

Before deregulation, the energy mix was under the control of the two countries' governments, but now the competitive market will dictate the mix of capacity additions. In this competitive environment, organizations are somewhat reluctant to release their capacity addition plans, but an estimate of minimum likely new generation has been made based on a number of sources and statements in interviews. Likely new generation in Australia is projected to total 16.6 GW by 2015 with 2.2 GW coal, 6.8 GW gas, 5.6 GW renewables, and 2 GW uncommitted. There is 1.5 GW of gas generation available in eastern Australia and 1.0 GW in western Australia which is expected to be utilized by 2000. Installation of gas-fired generation after 2000 will depend on the discovery and development of the production and transmission systems. The likely installation of a new generating plant in New Zealand by 2015 will total 1.7 GW with 0.6 GW gas, 0.4 GW renewables, and 0.7 GW of uncommitted.

Attitudes towards the clean coal technologies in Australia and New Zealand are dominated by the competitive market place and, as a result, clean coal technologies are not under active consideration in either country. However, if that situation were to change, existing and potential generators would evaluate the clean coal technologies using the following factors in their order of importance: required return on investment, environmental and political considerations, and capital costs. Under environmental factors, CO2, then NOx, SO2 and others are the emissions of concern in their order of importance. Where coal technology is under consideration for new capacity, subcritical PF is the technology of choice through 2000. IGCC is projected to be introduced beginning in 2005 and it will become the preferred alternative by 2010. AFBC and PFBC are thought to have limited application.

The barriers to the take-up of the clean coal technologies in Australia and New Zealand are again a direct result of the competitive situation in the electricity industry and can be divided into competition/economic and technical issues. The competitive/economic barriers center on whether the clean coal technologies can provide an acceptable return on investment, competitive capital costs, reduced construction period, and be competitive with gas-fired generation. On the technical side, barriers such as unit size greater than 500

MW, proven reliability, and a lack of information on the technical and cost characteristics are the primary issues. In some instances, existing or new generators had a limited understanding of the attributes of the clean coal technologies.

Beyond the competitive/economic issues, the environment also has a strong influence on the take-up of new technology. The environmental anti-coal lobby is becoming a growing force that must be considered. In addition, there are low cost CO2 mitigation strategies that will be considered before coal-fired technologies.

Consideration of policies and measures to overcome the barriers to the take-up of the clean coal technologies is not a well developed concept in Australia and New Zealand because the clean coal technologies are not under active consideration. In keeping with that situation, there appears to be a limited base of knowledge about the clean coal technologies that needs to be addressed by a better dissemination of pertinent information.

Japan

The assessment for Japan is taken from yearly reports to the Ministry of International Trade and Industry (MITI) prepared by the 10 regional electric utilities. Data on regional demand and demand growth is reported and organized by fuel type. Information concerning the take-up of the clean coal technologies was provided by both major equipment suppliers and the regional utilities. This information has been compiled into a report entitled "Study on Evolution of Energy-Efficient, Coal-Fired Generating Technology (Regional Studies Asia-Pacific)", prepared by the Electric Power Development Company.

The expansion of electricity generation installed capacity will continue to be driven, at least until the beginning of the 21st century, by the concept of diversification of the fuel mix to increase the security of supply. Power generation capacity in Japan is expected to increase by 101 GW through 2010. During the period 1996 through 2005, 70.7 GW of capacity will be added with 10.1 GW hydro, 21.7 GW coal, 26.5 GW LNG plus LPG, 0.4 GW of Orimulsion, 0.1 GW of geothermal and 14.6 GW of nuclear At the same time oil and other gas capacity will decrease by 2.0 GW.

Clean coal technologies will play a major role in the coal-fired capacity being planned. Ultra supercritical steam cycle (USC) technology and PFBC will play a major role in the new coal-fired capacity additions. Candidate projects, so dubbed because all details of the installations have not been finalized, account for 4.6 GW of capacity, 4.1 GW USC and 0.5 GW of PFBC. Japan currently has 16.6 GW of supercritical and USC and 400 MW of AFBC capacity operating in the country as well as a 70 MW PFBC unit. Two additional 350 MW PFBC units are in the planning stage.

Environmental regulation in Japan is becoming more and more severe. Citizen groups are taking a more active role in shaping agreements between the local authorities and the

utilities. In some situations power plants have had to install a dry flue gas desulfurization system based on scrubbing with activated char. This advanced emission control system has similar capital costs to FGD and SCR but has higher operating costs due to the activated char.

The Japanese Government has supported the take-up of the advanced flue gas desulfurization and selective catalytic reduction technologies, so far, by establishing a shorter depreciation period of 7 years as opposed to the normal 15 years. In addition, MITI often provides financial support for the demonstration of the clean coal technologies. However, recent moves to deregulate the electricity industry in Japan constitutes a new barrier to clean coal technologies in Japan. As a result, the cost factor and increased competition is causing the utilities to become more conservative in their choice of clean coal technologies and less able to accept long-term returns.

IV. CONCLUSIONS

The following discussion presents specific conclusions from the regional assessments:

OECD North America

- Growth in generating capacity in the region until 2015 is projected to be 204 GW with 21 GW of coal-fired capacity.
- The attitude towards the clean coal technologies is shaped by the following factors:
    - deregulation is delaying long-term decisions on capacity.
    - little need for base load capacity.
    - capital costs, reliability, fuel costs and environmental constraints are key criteria for selecting technology for new capacity additions.
- Barriers to the take-up of the clean coal technologies are:
    - increased availability of natural gas and relatively lower capital costs for natural-gas fired technologies.
    - high capital costs of PFBC and IGCC.
    - lack of commercially demonstrated reliability and operability.
    - lack of awareness of attributes by potential developers.
- Policies and measures that could overcome the barriers are:
    - change negative attitude of government and public towards coal.
    - provide financial and regulatory incentives, e.g. tax relief, specialized depreciation, financial support, and permitting relief for the early commercial applications (first 3 to 5 installations).
    - implement a program to inform IPP's and other developers on the virtues of the clean coal technologies.

OECD Europe

- Growth in generating capacity in the region until 2015 is projected to be 82 GW with 1 GW of coal-fired capacity.
- The attitude towards the clean coal technologies is shaped by the following factors:
    - deregulation has redefined priorities from reliability/availability to economic.
    - environmental limitations remain a strong consideration.
    - natural gas appears to have advantages in some countries where it is available and competitively priced.
    - countries with demonstration projects have a higher confidence in the clean coal technologies.
    - supercritical PF viewed as a proven technology in some countries.
- Barriers to the take-up of the clean coal technologies are:
    - low capital costs of natural gas-fired technologies.
    - opportunity for the installation of base-load coal-fired capacity negligible.
    - economic competitiveness in question.
    - uncertainty of commercial status and reliability of PFBC and IGCC.
- Policies and measures that could overcome the barriers are:
    - reduce capital cost through favorable financial incentives.
    - harmonize emission limits and energy taxes.
    - virtues of coal should be publicized.
    - conduct pilot/demonstration projects in more countries.

Southern Africa

- Growth in generating capacity in the region until 2015 is projected to be 24 GW with 18 GW of coal-fired capacity.
- The attitude towards the clean coal technologies is shaped by the following factors:
    - local and regional development takes precedent over technology choices.
    - coal and hydro are the preferred choices when capacity is required.
    - clean coal technologies are viewed favorably, but must be proven against competing options on a cost, availability and reliability basis.

- Barriers to the take-up of the clean coal technologies are:
    - no generating capacity required until after 2010.
    - existing capacity is relatively new.
    - hydro focus in the region.
    - perception is of high operating costs.
    - limited worker skills and supporting infrastructure.
    - deregulation and competition defer decisions and increase risk avoidance.

    - demonstration of acceptable environmental performance on local coal.
- Policies and measures that could overcome the barriers are:
    - catalyze economic growth.
    - apply joint implementation/activities implemented jointly provisions of the UN FCCC.
    - increase the communication of RD&D technology information.
    - improve costs, availability and reliability.
    - direct government intervention, e.g. financial incentives.

OECD Asia/Pacific

- Growth in generating capacity in the region until 2015 is projected to be 303 GW with 45 GW of coal-fired capacity and 43 GW of that installed in Japan.
- The attitude towards the clean coal technologies is shaped by the following factors:
    - deregulation/competition is becoming a significant factor in capacity choices.
    - environmental limitations are important.
    - Japan's capacity choices driven by national goal of diversification of fuel mix to increase the security of supply.
    - return on investment, environmental, politics and capital cost drive capacity decisions.
- Barriers to the take-up of the clean coal technologies are:
    - deregulation/competition in electricity industry.
    - lack of proven availability and financial risk at unit sizes greater than 500 MW.
    - trend toward cost cutting.
- Policies and measures that could over come the barriers are:
    - government financial incentives.
    - encourage market competition between technologies.
    - better methods for disseminating information.

V. REFERENCES

Regional Trends in the Evolution of Energy Efficient, Coal-Fired Power Generation Technologies, Coal Industry Advisory Board to the IEA, Paris, France, 2nd Draft October 1996.